Bacteria TMDL Development for the Elizabeth River

Final Public Meeting

Virginia Beach, VA

February 23, 2010

DEQ — VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

THE Louis Berger Group, INC.

Agenda

- **Meeting Objective**
- **Recap from Public Meeting #1**
- **Discuss the Bacteria TMDL Technical Approach**
- **Present the Preliminary TMDL Results**
- **Next Steps**

Objective

- **To present and review the <u>steps</u> and the <u>data</u> used in the development of a Bacteria TMDL for the Elizabeth River Watershed**

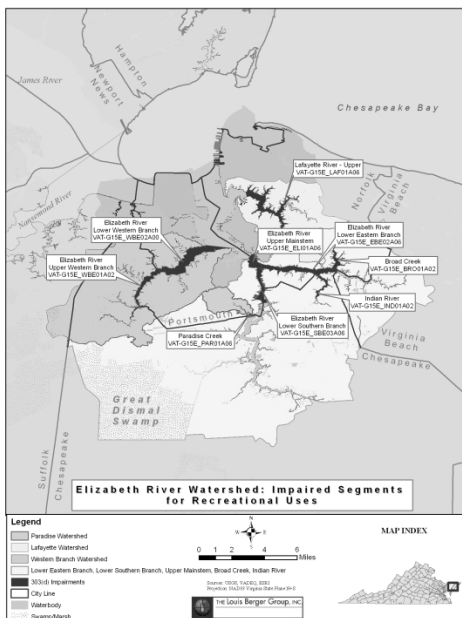- **To present the draft bacteria TMDL allocations for the Elizabeth River**

Bacteria TMDL Development Process
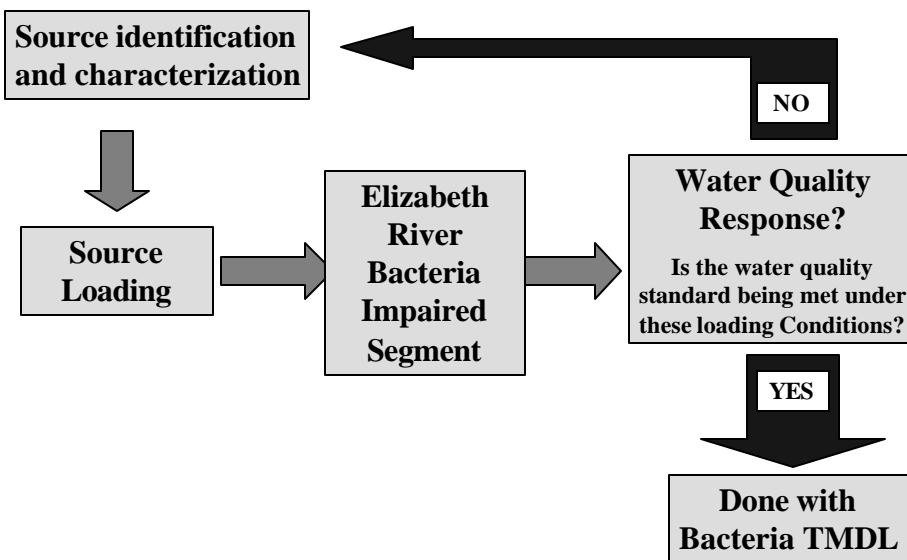
Bacteria Impairments in the Elizabeth River Watershed

Based on VADEQ 2008 303(d) List

Overview of the Elizabeth River Watershed

Elizabeth River Watershed: Impaired Segments for Recreational Uses

Total Acres: 139,847 acres

Five Cities:

➢ **City of Chesapeake (54%), City of Norfolk (21%), City of Portsmouth (14%), City of Virginia Beach (7%), and City of Suffolk (3%)**

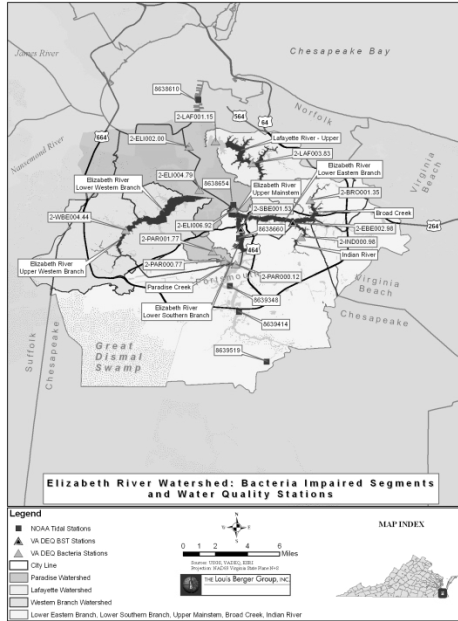➢ **Cities:**

  ➢ **Norfolk, Portsmouth, and Chesapeake**

Major Roads:

  ➢ **Interstate 664, 64, 264, 464, 564**

Main tributaries:

  ➢ **Western Branch, Southern Branch, Eastern Branch, and Lafayette River**

Bacteria Impaired Segments and Monitoring Stations

13 Bacteria Monitoring Stations maintained by VA DEQ

6 Tidal Stations maintained by NOAA

Bacteria Impairments
Based on VADEQ 2008 303(d) List

		Enterococci Impaired Segment Identification for the Elizabeth River			
TMDL Watershed	**Segment Name**	**2008 Assessment Unit**	**Cycle First Listed**	**Source**	**Estuary Size (miles²)**
TMDL #1		VAT-G15E_ELI01A06	2006	unknown	0.48
	Lower Southern Branch	VAT-G15E_SBE03A06	1998	unknown	0.58
	Lower Eastern Branch	VAT-G15E_EBE02A06	1998	unknown	1.02
		VAT-G15E_IND01A02	2006	unknown	0.268
	Broad Creek	VAT-G15E_BRO01A02	2006	unknown	0.37
TMDL #2	Lower Western Branch	VAT-G15E_WBE02A00	2004	unknown	1.46
	Upper Western Branch	VAT-G15E_WBE01A02	2004	unknown	0.56
TMDL #3	Upper Lafayette River	VAT-G15E_LAF01A06	2002	unknown	1.558
TMDL #4	Paradise Creek	VAT-G15E_PAR01A06	2006	unknown	0.06
Total					**6.356**

Water Quality Standards

VADEQ specifies the following bacteria criteria to protect primary contact recreational uses (VA DEQ, 2006):

- **Enterococci**
    - Geometric Mean:
        - 35 cfu/100ml (applies to 2 or more samples obtained in 1 calendar month)

    - Single Sample Maximum (SSM):
        - 104 cfu/100mL

VA DEQ Enterococci Exceedances at Stations in the Elizabeth River Watershed: All Tidal Conditions

Stream	Station ID	Sample Date		No. of Samples	Min*	Max*	Ave	Exceedances**	
		First	Last					SSM***	
					count/100mL	count/100mL	count/100mL	#	%
Mainstem	2-ELI006.92	7/25/2002	6/2/2009	80	10	520	58	10	13
	2-ELI004.79	8/15/2002	6/2/2009	79	10	550	38	4	5
	2-ELI002.00	7/23/2002	6/16/2009	75	10	100	26	0	0
Broad Creek	2-BRO001.35	9/24/2002	4/9/2009	39	25	2000	554	33	85
	2-IND000.98	7/31/2002	5/19/2009	38	20	2000	324	36	95
Lower Eastern Branch	2-EBE002.98	7/25/2002	6/2/2009	81	10	1800	96	10	12
Paradise Creek	2-PAR001.77	10/14/2003	6/17/2009	67	180	2000	986	67	100
	2-PAR000.77	10/14/2003	6/17/2009	66	25	2000	544	49	74
	2-PAR000.12	10/14/2003	6/17/2009	65	25	2000	269	25	38
Lower Southern Branch	2-SBE001.53	8/15/2002	6/2/2009	78	10	1800	141	18	23
Upper Western Branch	2-WBE004.44	8/15/2002	6/2/2009	78	10	2000	135	13	17
Lafayette River	2-LAF003.83	8/15/2002	6/2/2009	80	10	550	70	15	19
	2-LAF001.15	8/15/2002	1/0/1900	78	10	250	27	1	1

Summary of VA DEQ Enterococci Bacteria Events and Exceedances for the Elizabeth River

*Enterococci detection range is between 10 and 2000 count valuesper 100 mL. Therefore, recorded count values of 2000 could be greater than 2000 and count values of 25 could be less than 25.

** Requirements of at least two measurements per months for calculating geometric mean for enterococci were not met

*** Single Sample Maximum enterococci bacteria of 104 count/100mL.

Technical Approach

- **Bacteria Source Assessment**
  - ➢ Identify and assess all potential sources of bacteria in the Elizabeth River watershed
- **EPA Bacterial Indicator Tool**
  - ➢ Estimate bacteria contribution from multiple sources (livestock, pets, wildlife) and direct input of bacteria to streams from grazing livestock and failing septic systems
  - ➢ Estimate daily accumulated bacteria load per acre for each source
  - ➢ Estimate the distribution of the daily accumulated bacteria load
- **Simplified Volumetric Tidal Model**
  - ➢ Estimate existing and target bacteria loads for each potential source to link water quality and pollutant sources
- **Develop TMDL Allocations**

Simplified Volumetric Tidal Model

- Used for small watersheds
- Incorporates point and nonpoint sources
- EPA accepted
- Time independent
- Uses a mass balance approach over a tidal period (~12 hrs)
- Assumes a completely mixed system (no density, concentration, and volume variations)

Linking Sources to Water Quality

Input

Maximum bacteria concentration in the estuary

Maximum bacteria concentration at boundary at the mouth of the estuary

Volumes of water at sea level , entering the bay, flowing out of the bay, and net freshwater

Total daily bacteria die off rate

Model

Simplified Volumetric Tidal Model

Time Independent

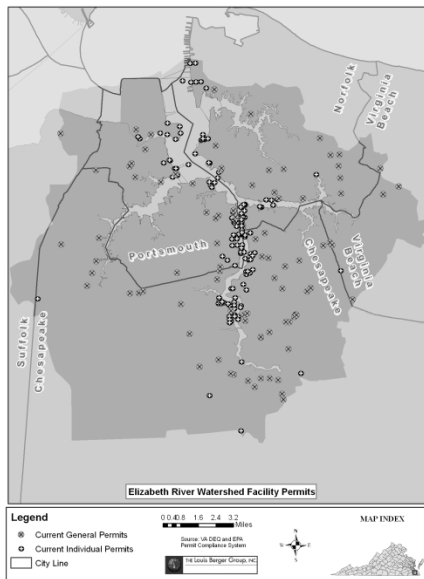Mass balance approach over a tidal period (~12 hrs)

Completely mixed system (no density, concentration, and volume variations)

Output

Total Bacteria Load Capacity in the Bacteria Impaired Estuary

➢ Existing Load

➢ Allocated Load

Bacteria Point Sources: Permitted Facilities

Elizabeth River Watershed Facility Permits

Legend
- Current General Permits
- Current Individual Permits
- City Line

0 0.4 0.8 1.6 2.4 3.2 Miles

Source: VA DEQ and EPA Permit Compliance System

The Louis Berger Group, Inc.

MAP INDEX

Total No. of Active Facilities: 145

Individual Permitted Facilities:

Permit Type	Number of Facilities
Industrial	51

General Permitted Facilities:

Permit Type	Number of Facilities
Stormwater	64
Car Wash, Cooling, Petrol, etc.	30
Total	94

Municipal Separate Storm Sewer Segment (MS4) Permit Holders

- **There are 5 MS4 permit holders in the Elizabeth River Watershed covering 80% of the Elizabeth River Watershed**

| MS4 Permit Acreage within the TMDL Watershed			
Permit Number	**MS4 Permit Holder**	**Total Permitted Acreage**	**Acreage within the Elizabeth River Watershed**
VA0088650	City of Norfolk	35,918	17,525
VA0088676	City of Virginia Beach	165,245	9,292
VA0088625	City of Chesapeake	224,079	71,535
VA0088668	City of Portsmouth	18,083	13,748
VA0090892	City of Suffolk	8,401	517
TOTAL		**443,325**	**112,099**

Potential Bacteria Sources

- **Bacteria loading from <u>Humans</u> (point sources, septic "failing or improperly functioning" systems, straight pipes, Sanitary Sewer Overflows, Marinas)**

- **Bacteria loading from <u>Livestock</u>**
  - Livestock inventories

- **Bacteria loading from <u>Wildlife</u>**
  - Wildlife Inventories

- **Bacteria loading from <u>Pets</u>**
  - Pet Inventories

Human Sources from Septic Failures and Straight Pipes

Population Estimates per TMDL Watershed

TMDL Watershed	City	Population	Number of Houses	Number of Houses Public Sewer	Number of Houses on Septic Systems	Number of Houses on "Other Means"	Number of Houses with a Failing Septic System
TMDL #1 Lower Eastern Branch Lower Southern Branch Indian River Broad Creek Upper Mainstem	Chesapeake	140,832	42,363	42,213	150	0	18
	Norfolk	43,531	15,714	15,680	34	0	4
	Portsmouth	26,425	7,932	7,927	5	0	0
	Virginia Beach	48,298	17,316	17,268	48	0	0
Total (TMDL #1)		**259,086**	**83,325**	**83,088**	**237**	**0**	**22**
TMDL #2 Western Branch	Chesapeake	37,027	11,671	11,567	104	0	12
	Portsmouth	40,858	14,184	14,115	69	0	0
Total (TMDL #2)		**77,885**	**25,855**	**25,682**	**173**	**0**	**12**
TMDL #3 Lafayette River	Norfolk	76,439	30,225	30,109	116		14
Total (TMDL #3)		**76,439**	**30,225**	**30,109**	**116**	**0**	**14**
TMDL #4 Paradise Creek	Portsmouth	9,360	2,927	2,925	2	0	0
Total (TMDL #4)		**9,360**	**2,927**	**2,925**	**2**	**0**	**0**

Data based on estimates provided by the City of Chesapeake, the City of Norfolk, the City of Portsmouth, the City of Suffolk and the City of Virginia Beach.

Livestock Estimates:
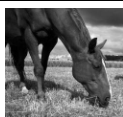
Livestock Estimates per TMDL Watershed

TMDL Watershed	City	Cattle	Pigs	Poultry	Horses	Sheep
TMDL #1 Lower Eastern Branch Lower Southern Branch Indian River Broad Creek Upper Mainstem	Chesapeake	200	75	0	100	0
	Norfolk	0	0	0	0	0
	Portsmouth	0	0	0	0	0
	Virginia Beach	0	0	0	0	0
Total		**200**	**75**	**0**	**100**	**0**
TMDL #2 Western Branch	Chesapeake	0	0	0	150	0
	Portsmouth	0	0	0	0	0
	Suffolk	0	0	0	15	0
Total		**0**	**0**	**0**	**165**	**0**
TMDL #3 Lafayette River	Norfolk	2	11	24	2	0
Total		**2**	**11**	**24**	**2**	**0**
TMDL #4 Paradise Creek	Portsmouth	0	0	0	0	0
Total		**0**	**0**	**0**	**0**	**0**

Data based on estimates provided by the City of Chesapeake, the City of Norfolk, the City of Portsmouth, the City of Suffolk and the City of Virginia Beach.

Wildlife Estimates:

Wildlife Present per TMDL Watershed [1]								
By TMDL Watershed	Canadian Geese [2]	Black Duck [2]	Wood Duck [2]	Mallard [2]	Deer [3]	Raccoon	Muskrat	Beaver
TMDL #1 (Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River)	164	0	0	164	3,014	3,164	945	339
TMDL #2 (Western Branch)	46	0	0	46	910	926	397	90
TMDL #3 (Lafayette River)	19	0	0	19	295	378	213	43
TMDL #4 (Paradise Creek)	3	0	0	3	61	29	23	5
[1] Based on information from the Virginia Department of Game and Inland Fisheries (DGIF) [2] Based on the Atlantic Flyway Breeding Waterfowl Survey of migrating birds (DGIF) [3] Based on DGIF population density of 0.047animals/acre (Acreages of entire watershed minus high and medium intensity developed, and water)								

Pets Estimates:

Pets Present per TMDL Watershed			
By TMDL watershed	Households[1]	Dogs[2]	Cats[2]
TMDL #1 (Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River)	83,325	45,245	49,412
TMDL #2 (Western Branch)	25,855	14,039	15,332
TMDL #3 (Lafayette River)	30,225	16,412	17,923
TMDL #4 (Paradise Creek)	2,927	1,589	1,736
TOTAL	**142,332**	**77,286**	**84,403**
[1] Provided by Isle of Wight County [2] Based on the number of households multiplied by pet unit numbers per household (Source: American Veterinary Medical Association)			

Source: American Veterinary Medical Association (AVMA)

Pet inventories based on:
- Cats: 0.598 per household and
- Dogs: 0.543 per household

Source Loading Estimates

Estimation of Bacterial Contribution in Each TMDL Watershed

- **EPA Bacterial Indicator Tool**

  ➢ Spreadsheet model using Microsoft EXCEL

  ➢ Estimates daily accumulated bacteria loads per source

Daily Bacteria Production by Source

Source	Bacteria Content in Bacteria Matter (million) (cfu/day)
Human	1,950
Pet	450
Horse	420
Beef Cattle	33,000
Dairy-Milked or dry Cow	25,200
Dairy-Heifer	11,592
Sheep	27,000
Deer	347
Raccoon	113
Muskrat	25
Beaver	0.2
Goose	799
Duck	2,430
Mallard	2,430
Wild Turkey	93
Hog	10,800
Chicken (Layer)	136

Source	The Equivalent Number of Sources to One Beef Cow
Human	16.92
Pet	73.33
Horse	78.57
Beef Cattle	**1.00**
Dairy-Milked or dry Cow	1.31
Dairy-Heifer	2.85
Sheep	1.22
Deer	95.10
Raccoon	292.04
Muskrat	1,320.00
Beaver	165,000.00
Goose	41.30
Duck	13.58
Mallard	13.58
Wild Turkey	354.84
Hog	3.06
Chicken (Layer)	242.65

NOTE: The bacteria content is based on analysis of the fecal matter from these sources.
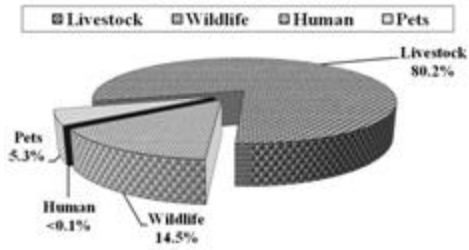
Sources: ASAE, Map Tech, Metcalf & Eddy,

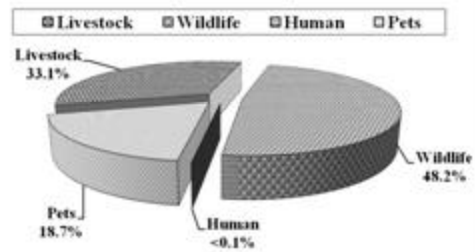# Preliminary Results of the Bacterial Contributions in each TMDL Watershed

- **EPA Bacterial Indicator Tool was used to calculate the NPS fractions for each TMDL Watershed.**

Estimated Bacterial Contribution by Source and TMDL Watershed				
TMDL Watershed	Livestock	Wildlife	Human	Pets
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Indian River, Broad Creek, Upper Mainstem	80.2%	14.5%	<0.1%	5.3%
TMDL #2 Western Branch	33.1%	48.2%	<0.1%	18.7%
TMDL #3 Lafayette River	0.0%	53.7%	<0.1%	46.3%
TMDL #4 Paradise Creek	0.0%	88.6%	<0.1%	11.4%

Bacteria Contribution by Source: TMDL # 1
(East and South Branch)

Livestock | Wildlife | Human | Pets

Livestock 80.2%
Pets 5.3%
Human <0.1%
Wildlife 14.5%

Bacteria Contribution by Source: TMDL # 2
(West Branch)

Livestock | Wildlife | Human | Pets

Livestock 33.1%
Wildlife 48.2%
Pets 18.7%
Human <0.1%

Bacteria Contribution by Source: TMDL # 3
(Lafayette River)

Livestock | Wildlife | Human | Pets

Human <0.1%
Pets 46.3%
Wildlife 53.7%
Livestock 0.0%
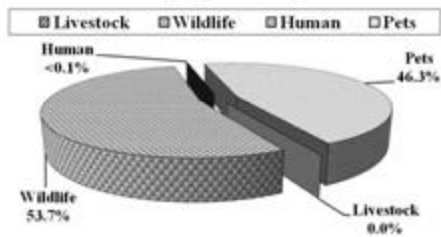
Bacteria Contribution by Source: TMDL # 4
(Paradise Creek)

Livestock | Wildlife | Human | Pets

Wildlife 88.6%
Human <0.1%
Pets 11.4%
Livestock 0.0%
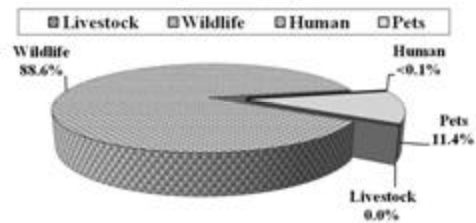
Existing Source Loading and Required Reductions

TMDL Watershed	Station	Maximum Measured Enterococci (Count/mL)	Current Load (Counts/day)	Allowable Load (Counts/day)	Required Reduction (%)
TMDL #1					
Lower Eastern Branch	2-EBE002.98	1800	7.24E+14	4.04E+13	94.4%
Lower Southern Branch	2-SBE001.53	1800	1.46E+15	8.26E+13	94.3%
Indian River	2-IND000.98	2000	4.91E+13	2.35E+12	95.2%
Broad Creek	2-BRO001.35	2000	2.08E+14	9.93E+12	95.2%
Upper Mainstem	2-ELI006.92	520	8.01E+13	1.61E+13	80.0%
Total for TMDL #1		**2000**	**2.80E+15**	**1.42E+14**	**94.9%**
TMDL #2					
Western Branch	2-WBE004.44	2000	7.33E+14	3.64E+13	**95.0%**
TMDL #3					
Lafayette River	2-LAF003.83	2000	5.97E+14	3.11E+13	**94.8%**
TMDL #4					
Paradise Creek	2-PAR001.77	2000	1.21E+13	5.79E+11	**95.2%**

TMDL Expression

$$\text{TMDL} = \grave{a}\ \text{LA} + \grave{a}\ \text{WLA} + \text{MOS}$$

LA = Load allocation (nonpoint source contribution)

WLA = Waste load allocation (point source contribution)

MOS = Margin of safety

TMDL Allocation Strategy

- **<u>Waste Load Allocation</u> is based on**
  - ➢permitted flow (design flow) and bacteria concentration at Permitted Facilities in the Elizabeth River Watershed,
  - ➢1% of the total allowable load for future growth, and
  - ➢the estimated fraction of NPS loads (using EPA's Bacterial Indicator Tool) from urban areas within the MS4s.
- **<u>Load Allocation</u> is based on**
- ➢ **the estimated fraction of NPS Loads (using EPA's Bacterial Indicator Tool) from the non urban areas**

TMDL #1 (Lower Eastern and Southern B., etc.):
TMDL Load Allocation (LA)

Load Allocation (Rural Sources)

Source	Distribution	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction
Livestock	80.2%	1.03E+15	5.61E+12	99%
Wildlife	14.5%	1.86E+14	5.85E+13	69%
Human	<0.1%	1.40E+10	0.00E+00	100%
Pets	5.3%	6.87E+13	3.74E+11	99%
Total	100.0%	1.28E+15	6.45E+13	95%

TMDL #1 (Lower Eastern and Southern B., etc.):
TMDL Waste Load Allocation (WLA)

1. One Percent of the total allowable load (MPN/day): 1.42E+12
2. MS4 Load

Lumped Waste Load Allocation (MS4s, urban areas)

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Norfolk	VA0088650			
City of Portsmouth	VA0088668	1.55E+15	7.64E+13	95%
City of Chesapeake	VA0088625			
City of Virginia Beach	VA0088676			

Waste Load Allocation for each MS4 (urban areas)

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Norfolk	VA0088650	2.54E+14	1.25E+13	95%
City of Portsmouth	VA0088668	1.32257E+14	6.50E+12	95%
City of Chesapeake	VA0088625	8.96E+14	4.40E+13	95%
City of Virginia Beach	VA0088676	2.73E+14	1.34E+13	95%
	Total	1.55E+15	7.64E+13	95%

TMDL #1 (Lower Eastern and Southern B., etc.):
Allocation Plan Loads

TMDL Allocation Plan Loads (Counts/day)

WLA (MS4s within urban area and 1% for future growth)	LA (Non MS4s and rural MS4s)	MOS (Margin of safety)	TMDL
7.78E+13	6.45E+13	IMPLICIT	1.42E+14

TMDL 2 (Western Branch): TMDL Load Allocation (LA)

Load Allocation (Rural Sources)

Source	Distribution	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction
Livestock	33.1%	1.02E+14	3.62E+11	100%
Wildlife	48.2%	1.48E+14	1.45E+13	90%
Human	<0.1%	1.69E+10	0.00E+00	100%
Pets	18.7%	5.74E+13	2.05E+11	100%
Total	**100.0%**	**3.07E+14**	**1.51E+13**	**95%**

TMDL 2 (Western Branch): TMDL Waste Load Allocation (WLA)

1. One Percent of the total allowable load (MPN/day): 3.64E+11
2. MS4 Load

Lumped Waste Load Allocation (MS4s, urban areas)

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Portsmouth	VA0088668			
City of Chesapeake	VA0088625	4.95E+14	2.10E+13	96%
City of Suffolk	VA0090892			

Waste Load Allocation for each MS4 (urban areas)

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Portsmouth	VA0088668	2.44E+14	1.03E+13	96%
City of Chesapeake	VA0088625	2.46E+14	1.04E+13	96%
City of Suffolk	VA0090892	5.19E+12	2.20E+11	96%
	Total	4.95E+14	2.10E+13	96%

TMDL 2 (Western Branch): TMDL Allocation Plan Loads

TMDL Allocation Plan Loads (Counts/day)

WLA (MS4s within urban area and 1% for future growth)	LA (Non MS4s and rural MS4s)	MOS (Margin of safety)	TMDL
2.13E+13	1.51E+13	IMPLICIT	3.64E+13

TMDL #3 (Lafayette R.): TMDL Source Loading and TMDL Allocations

Load Allocation (Rural Sources)

Source	Distribution	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction
Livestock	0.0%	0.00E+00	0.00E+00	0%
Wildlife	53.7%	9.50E+13	8.74E+12	91%
Human	<0.1%	2.87E+10	0.00E+00	100%
Pets	46.3%	8.19E+13	3.68E+11	100%
Total	100.0%	1.77E+14	9.11E+12	95%

Waste Load Allocation (MS4s, urban areas)
1. One Percent of the total allowable load (MPN/day): 3.11E+11
2. 2. MS4 Load

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Norfolk	VA0088650	4.61E+14	2.17E+13	95%

TMDL Allocation Plan Loads (Counts/day)

WLA (MS4s)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
2.20E+13	9.11E+12	IMPLICIT	3.11E+13

TMDL #4 (Paradise R.): TMDL Load Allocation (LA)

Load Allocation (Rural Sources)

Source	Distribution	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction
Livestock	0.0%	0.00E+00	0.00E+00	0%
Wildlife	88.6%	8.75E+11	4.27E+10	95%
Human	<0.1%	0.00E+00	0.00E+00	100%
Pets	11.4%	1.13E+11	3.98E+09	96%
Total	100.0%	9.88E+11	4.67E+10	95%

TMDL #4 (Paradise R.): TMDL Waste Load Allocation (WLA)

1. One Percent of the total allowable load (MPN/day): 5.79E+09
2. MS4 Load

Lumped Waste Load Allocation (MS4s, urban areas)

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Portsmouth	VA0088668	1.11E+13	5.26E+11	95%
City of Chesapeake	VA0088625			

Waste Load Allocation for each MS4 (urban areas)

MS4	Permit #	Existing Load (Counts/day)	Allocated Load (Counts/day)	Required Reduction (%)
City of Portsmouth	VA0088668	1.10E+13	5.19E+11	95%
City of Chesapeake	VA0088625	1.56E+11	7.35E+09	95%
	Total	1.11E+13	5.26E+11	95%

TMDL #4 (Paradise R.):
TMDL Allocation Plan Loads

TMDL Allocation Plan Loads (Counts/day)

| WLA (MS4s within urban area and 1% for future growth)	LA (Non MS4s and rural MS4s)	MOS (Margin of safety)	TMDL
5.32E+11	4.67E+10	IMPLICIT	5.79E+11

Next Steps

- **Finalize Draft TMDL Allocations**
- **Finalize Draft TMDL Report**

TMDL Contacts

Jennifer Howell, VA DEQ
5636 Southern Blvd
Virginia Beach, VA 23462
Phone: (757) 518-2111
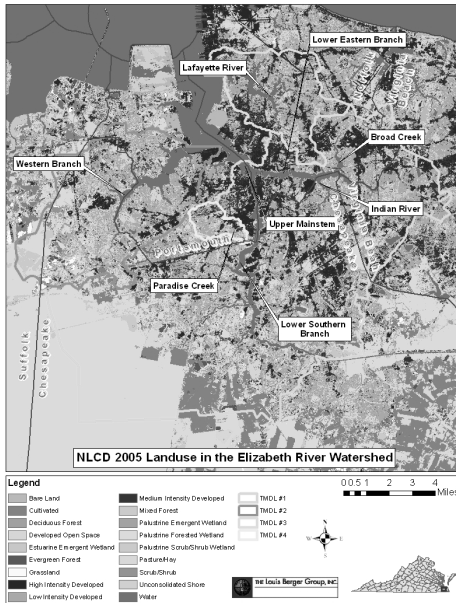Fax: (757) 518-2003
Email: Jennifer.howell@deq.virginia.gov

Reports/presentations available at:
www.deq.virginia.gov/tmdl/mtgppt.html
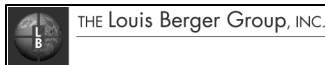
The Louis Berger Group, Inc.
Raed M. EL-Farhan
(202) 331-7775
relfarhan@louisberger.com

THE Louis Berger Group, INC.

Additional Slides

Watershed Landuse

NLCD 2005 Landuse in the Elizabeth River Watershed

Used the most recent land use data: NLCD 2005

Total Area: 139,847 acres

Urban: 70% (97,518 acres)

Water/Wetland: 19% (26,483 acres)

Agriculture: 1% (2,009 acres)

Forest: 5% (6,755 acres)

Other: 5% (7,082 acres)

Data from NCLD 2005

Watershed Landuse

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed (%)	Total Percent (%)
	Land Use within the Entire Elizabeth River Watershed				
	High Intensity Developed	12,508		9%	
	Medium Intensity Developed	20,048		14%	
	Low Intensity Developed	43,766		31%	
Developed	Developed Open Space	21,195	97,518	15%	70%
	Cultivated Crops	1,628		1%	
Agriculture	Pasture/Hay	381	2,009	>1%	1%
	Deciduous Forest	3,890		3%	
	Evergreen Forest	2,156		2%	
Forest	Mixed Forest	708	6,755	1%	5%
	Estuarine Emergent Wetland	3,198		2%	
	Estuarine Forested Wetland	>1		>1%	
	Estuarine Scrub/Shrub Wetland	95		>1%	
	Palustrine Emergent Wetland	456		>1%	
	Palustrine Forested Wetland	10,648		8%	
Wetlands	Palustrine Scrub/Shrub Wetland	2,027	16,424	1%	12%
	Palustrine Aquatic Bed	7		>1%	
Water	Water	10,052	10,059	7%	7%
	Barren Land	1,908		1%	
	Grassland (not used in agriculture)	761		1%	
	Scrub/Shrub	2,793		2%	
Other	Unconsolidated Shore	1,620	7,082	1%	5%
Total		**139,847**		**100%**	**100%**

Watershed Landuse: TMDL #1

Upper Mainstem, Lower Eastern Branch, Lower Southern Branch, Indian River, Broad Creek

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed (%)	Total Percent (%)
Land Use within TMDL #1					
	High Intensity Developed	5,471		7%	
	Medium Intensity Developed	9,138		25%	
	Low Intensity Developed	20,383		11%	
Developed	Developed Open Space	10,171	45,163	12%	55%
	Cultivated Crops	4,248		5%	
Agriculture	Pasture/Hay	703	4,951	1%	6%
	Deciduous Forest	1,919		2%	
	Evergreen Forest	1,007		1%	
Forest	Mixed Forest	344	3,270	>1%	4%
	Estuarine Emergent Wetland	1,823		2%	
	Estuarine Forested Wetland	>1		>1%	
	Estuarine Scrub/Shrub Wetland	63		>1%	
	Palustrine Emergent Wetland	267		>1%	
	Palustrine Forested Wetland	19,972		>1%	
Wetlands	Palustrine Scrub/Shrub Wetland	1,070	23,194	24%	28%
	Palustrine Aquatic Bed	3		1%	
Water	Water	4,000	4,003	5%	5%
	Barren Land	138		>1%	
	Grassland (not used in agriculture)	366		>1%	
	Scrub/Shrub	1,606		2%	
Other	Unconsolidated Shore	46	2,155	>1%	3%
Total		**82,736**		**100%**	**100%**

Watershed Landuse: TMDL #2

Western Branch

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed (%)	Total Percent (%)
Land Use within TMDL #2					
	High Intensity Developed	1,186		5%	
	Medium Intensity Developed	1,745		7%	
	Low Intensity Developed	7,070		30%	
Developed	Developed Open Space	4,058	14,059	17%	59%
	Cultivated Crops	289		1%	
Agriculture	Pasture/Hay	129	418	1%	2%
	Deciduous Forest	1,052		4%	
	Evergreen Forest	573		2%	
Forest	Mixed Forest	196	1,821	1%	8%
	Estuarine Emergent Wetland	518		2%	
	Estuarine Forested Wetland	>1		>1%	
	Estuarine Scrub/Shrub Wetland	16		>1%	
	Palustrine Emergent Wetland	48		>1%	
	Palustrine Forested Wetland	3,327		14%	
Wetlands	Palustrine Scrub/Shrub Wetland	1,021	4,930	4%	21%
	Palustrine Aquatic Bed	1		>1%	
Water	Water	1,655	1,656	7%	7%
	Barren Land	9		>1%	
	Grassland (not used in agriculture)	258		1%	
	Scrub/Shrub	793		3%	
Other	Unconsolidated Shore	5	1,065	>1%	4%
Total		**23,951**		**100%**	**100%**

Watershed Landuse: TMDL #3
Lafayette River

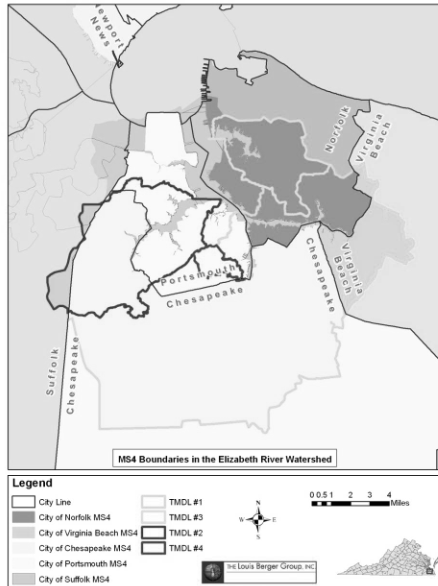| Land Use within TMDL #3					
General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed (%)	Total Percent (%)
Developed	High Intensity Developed	932		9%	
	Medium Intensity Developed	1,875		18%	
	Low Intensity Developed	4,090		40%	
	Developed Open Space	1,185	8,082	12%	78%
Forest	Deciduous Forest	156		2%	
	Evergreen Forest	183		2%	
	Mixed Forest	16	354	>1%	3%
Wetlands	Estuarine Emergent Wetland	209		2%	
	Estuarine Scrub/Shrub Wetland	7		>1%	
	Palustrine Emergent Wetland	38		>1%	
	Palustrine Forested Wetland	267		3%	
	Palustrine Scrub/Shrub Wetland	20	542	>1%	5%
	Palustrine Aquatic Bed	1		>1%	
Water	Water	1,229	1,230	12%	12%
Other	Barren Land	2		>1%	
	Grassland (not used in agriculture)	>1		>1%	
	Scrub/Shrub	91		1%	
	Unconsolidated Shore	4	97	>1%	1%
Total		10,304		100%	100%

Watershed Landuse: TMDL #4
Paradise Creek

Land Use within TMDL #4					
General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed (%)	Total Percent (%)
Developed	High Intensity Developed	111		6%	
	Medium Intensity Developed	291		17%	
	Low Intensity Developed	779		45%	
	Developed Open Space	402	1,584	23%	92%
Forest	Deciduous Forest	10		1%	
	Evergreen Forest	1		>1%	
	Mixed Forest	5	16	>1%	1%
Wetlands	Estuarine Emergent Wetland	37		2%	
	Estuarine Scrub/Shrub Wetland	2		>1%	
	Palustrine Emergent Wetland	4		>1%	
	Palustrine Forested Wetland	23		1%	
	Palustrine Scrub/Shrub Wetland	3	69	>1%	4%
Water	Water	20	20	1%	1%
Other	Barren Land	1		>1%	
	Grassland (not used in agriculture)	2		>1%	
	Scrub/Shrub	24		1%	
	Unconsolidated Shore	>1	27	>1%	2%
Total		1,716		100%	100%

MS4 Permitted Areas

MS4 Boundaries in the Elizabeth River Watershed

Legend

City Line	TMDL #1
City of Norfolk MS4	TMDL #3
City of Virginia Beach MS4	TMDL #2
City of Chesapeake MS4	TMDL #4
City of Portsmouth MS4	
City of Suffolk MS4	

0 0.5 1   2   3   4 Miles

THE Louis Berger Group, INC.

Wildlife Distribution Estimates

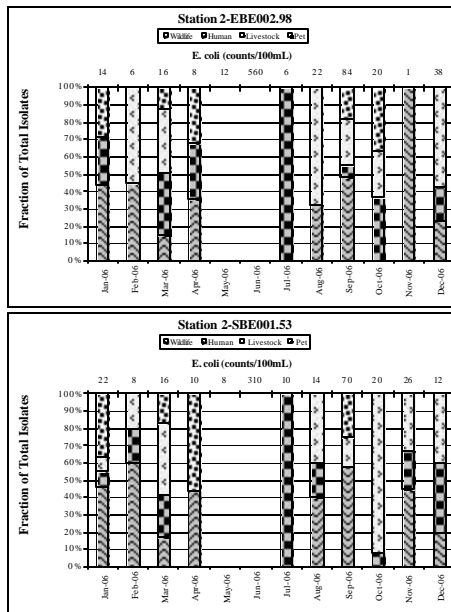| Wildlife Densities in the TMDL Watersheds[1]		
Wildlife type	**Population Density**	**Habitat Requirements**
Deer	0.047 animals/acre	Entire watershed minus high and medium intensity developed, and water
Raccoon (low density)	10/square mile	Upland forest
Raccoon (high density)	50/square mile	Bottomland forest, marsh, swamp, along streams
Muskrat (low density)	2 animals/mile	16/mile of ditch or medium sized stream intersecting agriculture crop fields, 8/mi of medium sized stream intersecting pasture fields, 10/mi of pond or lake edge, 50/mi of slow-moving river
Muskrat (high density)	15 animals/mile	
Muskrat (average density)	10 animals/mile	
Beaver (low density)	1.0/mile	Permanent streams and rivers
Beaver (high density)	14.5/mile	
Beaver (average density)	4.8/mile	
Goose	0.02 animals/acre	Entire Watershed
Canadian Goose	http://migbirdapps.fws.gov/	Based on particular strata for watershed area
Mallard		
Wood Duck		
Black Duck		
Wild Turkey	0.01 animals/acre	Entire watershed excluding urban land uses
[1] Source: Department of Game and Inland Fisheries (DGIF)		

Bacteria Source Tracking (BST)

- **BST data were collected at two stations by Virginia Department of Health (VDH)**
  - Lower Eastern Branch (2-EBE002.98) – TMDL #1
  - Lower Southern Branch (2-SBS001.53) – TMDL #1

- **Results indicate that bacteria sources from human, livestock, wildlife, and pets are present in the watershed**

Location of Monitoring Stations for Bacteria Source Tracking (BST)

Elizabeth River Watershed: Location of BST Stations in Impaired Segments for Recreational Uses

Bacteria Source Tracking
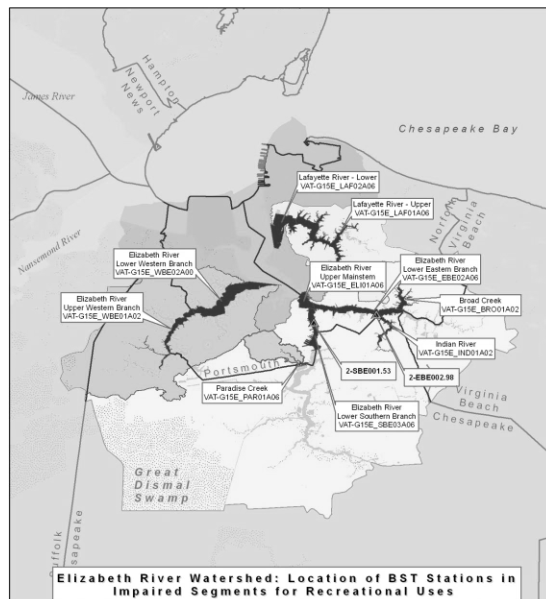
Station 2-EBE002.98

Station 2-SBE001.53

Bacteria Source Tracking

Computed Weighted BST Fractions					
	TMDL #1	Wildlife	Human	Livestock	Pets
Station	2-SBE001.53	46%	7%	26%	21%
	2-EBE002.98	33%	13%	35%	19%